

Vermont Space Grant Consortium
University of Vermont, Lead Institution
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PROGRAM DESCRIPTION

The National Space Grant College and Fellowship Program consists of 52 state-based, university-led Space Grant Consortia in each of the 50 states plus the District of Columbia and the Commonwealth of Puerto Rico. Annually, each consortium receives funds to develop and implement student fellowships and scholarships programs; interdisciplinary space-related research infrastructure, education, and public service programs; and cooperative initiatives with industry, research laboratories, and state, local, and other governments. Space Grant operates at the intersection of NASA's interest as implemented by alignment with the Mission Directorates and the state's interests. Although it is primarily a higher education program, Space Grant programs encompass the entire length of the education pipeline, including elementary/secondary and informal education. The Vermont Space Grant Consortium is a Capability Enhancement Consortium funded at a level of \$660,000 for fiscal year 2010.

PROGRAM GOALS

Goals of the Vermont Space Grant Consortium (VTSGC) during the first year of our current five-year award included continuing to develop our network of colleges and universities, industries, and other organizations interested in strengthening mathematics and science so as to increase interest and capabilities in aeronautics, space and related fields in the State of Vermont. The VTSGC has sought to encourage students at all levels from K-12 through university and graduate school to take more mathematics and science, to make connections with NASA, and to consider careers in scientific and technical fields. Through our Undergraduate Scholarship, Graduate Fellowship, and Higher Education Programs, the VTSGC has addressed critical pipeline issues, helped train the next generation of professionals, and has especially encouraged women, members of underrepresented groups, and persons with disabilities. As a Capability Enhancement Consortium, a priority for the VTSGC during the period of this award has been to enhance research infrastructure in Vermont, especially the capability to engage in research of an interdisciplinary nature. These goals and objectives, as well as the methods to be used to achieve them, are detailed in the VTSGC's Strategic Plan. A copy of the VTSGC's Vision Statement, Mission Statement and Strategic Plan can be seen on the VTSGC's website at the URL above.

PROGRAM/PROJECT BENEFIT TO OUTCOME (1,2, OR 3)

Several illustrations will highlight the contributions made by VTSGC programs to the three outcomes that guide NASA's Education Portfolio. As a first illustration, after an

extensive university-wide review and evaluation of existing research activity, the University of Vermont (UVM), the Lead Institution in the VTSGC, is currently in the process of implementing a Transdisciplinary Research Initiative (TRI). Within this initiative, UVM's initial strategic goal is to develop three "Spires of Excellence" to expand, coordinate, and leverage research capability in areas at the intersection of important State and National interest where UVM already has significant research assets. Of particular relevance to NASA research priorities is the new TRI Spire in Complex Systems. Prof. Chris Danforth, an applied mathematician with strong links to NASA collaborators at NASA Goddard whose research involves reducing uncertainty in weather and climate model forecasts, is playing a leading role in the development of the Complex Systems TRI Spire. To support this new opportunity for both research and human resource development, the VTSGC awarded a Graduate Research Fellowship to Prof. Danforth's Ph.D. student Nicholas Allgaier in our 2010 Graduate Fellowship Competition. To supplement this graduate student support, Prof. Danforth was also awarded a Research Minigrant in our 2010 Faculty Research Competition with funding to travel to NASA Goddard to visit Dr. Robert Cahalan, Head of the Climate and Radiation Branch at GSEC, his NASA collaborator. Consequently, through the 2010 Graduate Research Fellowship and Research Minigrant awarded to this project, the VTSGC has not only directly supported state research infrastructure development, but we have contributed to the development of the STEM workforce in a discipline needed to achieve NASA's strategic goals (Outcome 1, *Employ and Educate*), and have facilitated the development of new NASA-relevant STEM educational opportunities for students and faculty (Outcome 2, *Educate and Engage*).

A second illustration of how VTSGC programs benefit NASA's Education Outcomes comes from our Higher Education Programs and involves support for the Autonomous Underwater Vehicle (AUV) Project at Norwich University, a VTSGC affiliate. The undergraduate student engineering team (4 members) involved in this project is developing a robot vehicle that will be 100% self-controlled and capable of navigating through a series of predefined tasks without human intervention. This project, which was initially supported using ESMD Higher Education funding in 2007, was so popular and successful that the VTSGC has provided follow-on funding from our main NASA award in FY 2010. This past year, the team designed a new AUV hull and propulsion system that will support the harsh environment of navigating under the ice crust in Lake Champlain in support of NASA's mission of autonomous navigation for harsh environments in space. This development may be applicable to a future NASA mission planned to seek signs of life below a 3 to 5 kilometer thick ice sheet on the surface of the Jovian moon Europa. The team also strengthened contacts with NASA researchers. Indeed, as a result of the enhanced NASA links, one student on the 2009-2010 team participated in the "Engineering Boot Camp" Program at NASA Goddard during the summer of 2010. In addition, a crosscutting feature of this project is an interaction of team members with 7th graders and their parents at the U32 School in Norwich, Vermont. This interaction not only has encouraged the 7th grade students to take more mathematics and science but also has promoted an increased awareness of NASA and its mission in the larger Norwich community (Outcome 3, *Engage and Inspire*).

A final illustration of the benefit to NASA Education Outcomes of our programs involves the VTSGC Awards Night Ceremony held in October last year. Students, their parents, and representatives of VTSGC affiliates, local school boards, and the State of Vermont attended this yearly ceremony, which honors students supported by the VTSGC's Fellowship/Scholarship, Higher Education, and Research Infrastructure programs. The 2010 Awards Night program included presentations by Vermont students who participated in VTSGC-supported NASA Summer Internships and mentored undergraduate research projects as well as demonstrations by supported student teams, such as the UVM Alternative Energy Racing Organization (AERO) Team. It is a measure of the standing the VTSGC has now achieved in our state that Vermont's then Governor, Jim Douglas, and then Lieutenant Governor, Brian Dubie, although they could not personally attend, sent signed letters of congratulations to our 2010 award recipients. A representative from Senator Patrick Leahy's office also attended the ceremony and brought similar congratulatory letters for awardees signed by Senator Leahy. Our Awards Night generated considerable publicity for both the VTSGC and NASA in local media across the entire state and helped to highlight strategic partnerships with formal and informal STEM education providers, promote our efforts to advance STEM literacy, and raise awareness of NASA's mission among both Vermont's education community and the General Public (Outcome 3).

PROGRAM ACCOMPLISHMENTS

Outcome 1: Contribute to the development of the STEM workforce in disciplines needed to achieve NASA's strategic goals (Employ and Educate)

In order to provide NASA related competency-building education and research opportunities for students and faculty researchers, the VTSGC has strived to make significant achievements and progress in our Research Infrastructure, Fellowship/Scholarship and Higher Education programs. These are described in detail under the following three sub-headings:

1.1 Research Infrastructure:

As a Capability Enhancement Consortium, a priority goal of the VTSGC is increasing Vermont's Research Infrastructure in areas aligned with new and continuing NASA research priorities. Vermont's NASA EPSCoR Program shares this goal. There is close cooperation and coordination between the VTSGC and VT-NASA EPSCoR in this area. Several of our local faculty research awards are jointly funded by the VTSGC and VT-NASA EPSCoR, resources for local VT-NASA EPSCoR projects have been augmented by VTSGC Graduate Fellowship awards, and several Science PI's for VT-NASA EPSCoR's research team projects that are currently funded by National NASA EPSCoR Research Competition awards initiated their research projects using VTSGC Minigrants.

The primary program used by the VTSGC to promote the development of Vermont's research infrastructure is our yearly Faculty Research Proposal Competition. This competition is open to all full-time Vermont researchers at any Vermont college or

university. Research Minigrants grants of up to \$5,000 to initiate research projects and collaborations with NASA colleagues and Small-Scale Grants of up to \$30,000 for more mature research projects, particularly those where a NASA contact has already been made, are available to faculty researchers through this competition. Potential uses of Research Minigrants include seed money to explore initiating NASA-related research projects, travel to a NASA Center to establish contact or collaborate with an appropriate NASA colleague, bringing a distinguished visitor or research collaborator to Vermont for a short visit, and summer support of an undergraduate or graduate student. The more extensive Small-Scale Research Grants may contain summer faculty research salary or research support for a graduate student. Small-Scale Grants typically contain travel funds to visit a NASA Center to establish or strengthen NASA collaboration, and a further expectation is the submission of a research proposal for follow-on funding from non-Space Grant and non-EPSCoR sources. For both Minigrants and Small-Scale Grants, significant cost share is required from the PI's home department or institution to demonstrate support for and a commitment to the research project.

Six new faculty research grants were awarded during the past year as a result of our 2009 Faculty Research Competition. Four of these awards were Small-Scale Grants, and two were Research Minigrants. Four additional related research projects were also supported in supplemental funding from the VTSGC's 2009 CDC Award, the Vermont Frozen Landscape Monitoring Project, but these will be detailed in a separate report.

Funded Small-Scale Grants in FY 2010 included an award to Prof. Jeff Frolik and Prof. Christian Skalka of the UVM School of Engineering (SoE). Prof. Frolik is the Research Coordinator of the Snowpack and Snow-Water Equivalent Faculty Research Team and the Science PI for Vermont's 2010 CDC award. Additional team members in FY 2010 were Beverly Wemple of Geography and Jennifer Pontius of the Rubenstein School of Environment and Natural resources at UVM, and Jason Schafer of Meteorology at Lyndon State College. A FY 2009 small-scale grant from the VTSGC to Prof. Frolik allowed this research team to obtain the preliminary results that led to the 2010 CDC award. This new Small-Scale Grant leverages the 2010 CDC funding by supporting travel to NASA as well as the purchase of equipment. A further augmentation for this project is a VTSGC Graduate Research Fellowship providing support for an additional graduate student (female) doing thesis research on this topic. Funding for a portion of the current award to Profs. Frolik and Skalka is being provided by VT-NASA EPSCoR. This VTSGC Small-Scale Grant is thus an example of the close cooperation and coordination between the VTSGC and VT-NASA EPSCoR in our joint efforts to enhance Vermont's Research Infrastructure in NASA-relevant areas.

A second Small-Scale Grant was awarded to Prof. Christopher Danforth of Mathematics at UVM. Prof. Darren Hitt of Mechanical Engineering at UVM is also a participant in the proposed research. This award has allowed Prof. Danforth to continue his collaboration with Dr. Robert F. Cahalan, Head of the Climate and Radiation Branch at the Goddard Space Flight Center. Dr. Cahalan informally co-advised Prof. Danforth's Ph.D. thesis at the University of Maryland, College Park from 2001-2006. An expectation of all VTSGC small-scale grants is that the faculty researchers will write at

least one proposal to a Federal agency for follow-on funding through regular National competitive channels. Prof. Danforth has done this, and I'm pleased to be able to report that a proposal to NSF to provide support for a Postdoctoral Assistant has now been funded. Prof. Danforth has told us that preliminary results obtained with VTSGC seed funding are directly responsible for this award. He is also exploring additional funding opportunities through regular channels at NASA. His project appears to be well on its way to "graduating" from our seed money Faculty Research Program and becoming self-sustaining through a combination of NSF and NASA awards.

Two additional new Small-Scale Grants were awarded in FY 2010 to Prof. Joanna Ellis-Monaghan of St. Michael's College, and Prof. Marcia Collaer of Middlebury College and Prof. Anthony Richardson of St. Michael's College. Both of these projects involve significant participation by undergraduate student researchers. These awards thus support a VTSGC goal of encouraging mentored research experiences for undergraduates as well as supporting our efforts to encourage faculty researchers at primarily undergraduate teaching institutions to remain research active and develop links to NASA.

The two research Minigrants awarded in the VTSGC's 2010 Faculty Research Competition were made to Prof. Mary Dunlop and Prof. Dryver Huston, both of UVM's SoE. A value added feature of the Dunlop award is that it is assisting in the development of Biomedical Engineering as a new area of emphasis within UVM's College of Engineering and Mathematical Sciences and College of Medicine. Indeed, the current MS level graduate program in this area is in the process of being upgraded to a PhD program that spans multiple UVM colleges. The VTSGC has established itself as a significant stakeholder in this effort. Prof. Dunlop is not only an expert in this research area, but she is a new junior faculty member just recruited this year to UVM's SoE who has expressed an interest in initiating research that is strongly aligned with new and continuing NASA research priorities.

Vermont's NASA EPSCoR Program currently supports much of Vermont's academic faculty research in areas of interest to NASA. However, as indicated by the above awards, the VTSGC remains an active participant in efforts to expand and enhance Vermont's NASA-related research infrastructure and build further research ties between Vermont's academic faculty and NASA.

A comparison of the progress reported above with the SMART goals and objectives described in the VTSGC's FY 2010 proposal package for Year 1 of the current funding cycle shows that all targets for the current reporting period have been met. The target range for faculty awards in our FY 2010 proposal included four Small-Scale Grants and two Research Minigrant. As noted above, this is the distribution of local faculty research awards that were, in fact, supported by the VTSGC using FY 2010 funding. As was pointed out earlier, these Research Grants will help to build and strengthen research ties between Vermont's academic faculty and NASA. Of the nine Faculty Investigators involved in these locally funded research projects, four are women. This exceeds our target of 40% in this area. None of the Faculty Investigators supported this year are members of a minority group that is underrepresented in STEM disciplines. However,

because statistics show that Vermont has an exceedingly small number of STEM faculty members from underrepresented groups, our goal in this area is a five-year, rather than a year-to year, target. As previously noted, progress on the Vermont Frozen Landscape Monitoring Project, funded by our 2010 CDC award, will be reported separately. However, I would note that one member of the faculty team for that project is Hispanic. Further, two of the five members of the faculty team for that project are women.

1.2 Undergraduate Scholarship and Graduate Research Fellowship Competitions:

Results of the sixteenth Vermont Space Grant Undergraduate Scholarship Competition were announced in May 2010 with undergraduate scholarships awarded for the 2010-2011 academic year. In the general competition, three merit-based scholarships were awarded to outstanding Vermont students who will be attending Vermont institutions of higher learning throughout the state. Through a Memorandum of Understanding with the Abenaki Tribal Council of Vermont, four additional VTSGC Native American Undergraduate Scholarships were also awarded to outstanding scholars of Abenaki heritage. Four of these thirteen scholars were women. Thus, both our target of 40% undergraduate scholarships awarded to women contained in our FY 2010 proposal and our target of 25% awarded to members of underrepresented groups were exceeded. All supported undergraduate students appear to be making excellent progress toward their baccalaureate degrees.

Three additional special scholarships of \$2,500 each were awarded during the current reporting period to students in the Aviation Technology School of the Burlington Technical Center, a VTSGC affiliate. This School has a 100% employment record, and graduates of its program, which is one of the premier programs in North America that train certified aviation and powerframe technicians, are usually offered employment either before or within hours of graduation. Because the school calendar for this program differs significantly from the usual academic year, students in this program cannot reasonably compete in the VTSGC's normal Undergraduate Scholarship Competition. To address the special needs of this affiliate, these scholarships were first authorized by the VTSGC's Board of Advisor in 2003 as part of our efforts to develop and expand the scientific and technical workforce needed in the future by NASA and aerospace companies in the private sector.

An additional VTSGC special scholarship was awarded to Benjamin Scaria, a Vermont resident and undergraduate student at Rennselaer Polytechnic Institute (RPI), to support a 2010 Summer Internship at Goddard Space Flight Center. Mr. Scaria's internship activities included work "Probing the Early Universe Through Measurement of the Polarization of the Cosmic Microwave Background." with Dr. David Chuss in the NASA Observational Cosmology Laboratory.

In terms of graduate fellowships, the University of Vermont is the only comprehensive institution in the entire State granting graduate degrees in mathematics, science and engineering. This fact explains why the VTSGC Graduate Research Fellowships have been for graduate study at UVM. Fortunately, UVM's graduate programs in

mathematics, science and engineering are strong and thriving, especially in the biomedical and remote sensing areas that form the research focus of NASA-related research in Vermont. It is important to note that our graduate awards have a strong research component and are not simply pure fellowships. Recipients work with UVM researchers who have, or are developing links to NASA, and the awards usually contain a summer research stipend as a component.

Five Graduate Research Fellowships that fully supported graduate students for 12-month periods including the 2010-2011 academic year were competitively awarded in the VTSGC's 2010 Graduate Research Competition. Three additional Graduate Fellowships were also partially supported by the VTSGC using FY 2010 funding as a result of the 2010 competition. In aggregate, this is equivalent to the target of six full-time awards and one partial award stated in our FY 2010 base budget and augmentation proposals. Two of the eight supported students are women. At 25%, the results for women awarded VTSGC Graduate Fellowships during the present reporting period are under our goal of at least 40% awarded to female graduate students. However, based on experience in prior reporting periods, we are confident that we will be able to meet our goal for participation by women in this program over the full five-year period. Unfortunately, the same statement cannot be made about meeting our target of awarding two Graduate Fellowships to members of an underrepresented group during the 5-year period of our Space Grant award. None of the graduate students supported in FY 2010 from our base and augmentation funding was a member of an underrepresented group. (However, one graduate student in our 2010 CDC effort is Hispanic.) Faculty mentors are always strongly encouraged to propose GRA funding for women, members of underrepresented groups, and persons with disabilities in our yearly Graduate Research Competitions.

Our graduate fellowship program is producing excellent outcomes. All graduate students awarded VTSGC Graduate fellowships during the present reporting period are making excellent progress toward earning their degrees.

1.3 Higher Education Programs:

In 1996, the VTSGC initiated a category of awards called Undergraduate Program Projects to fund many of our efforts in Higher Education. In the just concluded reporting period, two supported activities in this category were the UVM Alternative Energy Racing Organization (AERO) Student Team and Norwich University's Autonomous Underwater Robotic Vehicle (AUV).

Professors Danner Friend and Jacques Beneat of Norwich University's Departments of Mechanical Engineering and Electrical and Computer Engineering are the faculty mentors for the Norwich AUV Student Teams. The 2010 Program Project Grants for this engineering design team provided additional follow-on funding for design efforts that were initiated with earlier ESMD-Space Grant awards. Prototype vehicles designed, built, and tested by both of this student team have successfully competed in national engineering competitions. The efforts of the Norwich AUV team have already been

noted at the start of this progress report as one example of how the VTSGC's Higher Education programs benefit NASA's Education Outcomes.

The achievements of the UVM AERO Team provide an additional example of how VTSGC Higher Education efforts benefit NASA Education Outcomes. Prof. Jeff Frolik of UVM's Department of Electrical and Computer Engineering is the faculty mentor for this undergraduate student engineering team of 30 active members, of whom 6 are women. Participation in team activities has provided a pathway to professional employment in Green Energy areas. Recent AERO alumni now work for GM's hybrid drivetrain division, Vermont alternative energy developers, and hybrid vehicle startup companies in New England.

The AERO Team competed in its third Formula Hybrid International Competition (FHIC) in May 2010. Its hybrid vehicle, which uses both gas and lithium batteries and burns gas more efficiently through regenerative braking, participated in all events and placed first in the all electric acceleration and second in the hybrid-drive acceleration tests. Overall, the team place 8th among the 23 teams with operation vehicles. AERO is currently preparing its third generation vehicle (GreenSpeed Gen3) for the 2011 FHIC competition. The design includes a significantly improved chassis, improved driver ergonomics and a more resilient battery system. The team has also been invited to a special event 'Showcase of Alternative Energy' preceding the running of the Indianapolis 500.

Other Higher Education activities supported by the VTSGC during the present reporting period enhanced the baccalaureate experience of undergraduate students at Vermont colleges and universities through funding faculty-mentored undergraduate research projects while strengthening faculty research efforts and building ties to NASA. Of the seven undergraduate students participating in these research projects, three were women and one is Hispanic. Of the seven faculty mentors involved in these research projects, two were women.

At St. Michael's College (SMC) in Colchester, VT, Prof. Sue Kadas has coordinated mentored undergraduate research projects on topics of interest to NASA involving students in STEM disciplines during the academic year or the summer. Prof. Kadas is the SMC representative to the VTSGC's Board of Advisors. During the current reporting period, Professor Donna Bozzone of SMC's Department of Biology mentored SMC student Jason Berglund in the 2010 academic year on a research project titled "The Effects of South Asian Spices and Oral Bacteria on Overall Tooth Health: An Empirical Test of the Antimicrobial Hypothesis," and in summer 2010 Prof. Anthony Richardson and Prof. Melissa VanderKaay Tomaslo of the Department of Psychology mentored Eric Hanko on "The Effect of Stress on Virtual Navigation, Spatial Attention, and Physiological Processes in Males and Females." Prof. James Byrne coordinated a similar program of mentored undergraduate research at Norwich University. Prof. Byrne is a Vice Provost at Norwich and Norwich's representative to the VTSGC Board of Advisors. The Norwich program during the current reporting period involved a summer project in which faculty mentors Danner Friend and Jacques Beneat mentored Norwich

undergraduates Karina Delgado (female, Hispanic, Electrical and Computer Engineering), Robert Martin (male, Mechanical Engineering), and Laura Whitney (female, Mechanical Engineering) studying “Navigation and Attitude Determination Sensor System for CubeSat Lunar Spacecraft.”

During the current reporting period, the VTSGC also supported two mentored undergraduate research projects in the UVM Ureca! Program, coordinated by the Dean of the UVM Honors College. The aim of this program is to provide undergraduate students in all disciplines at UVM an opportunity to engage in a mentored research experience that is "over and above" the research component of a course taken for academic credit. The Ureca! Competition is structured so as to model a real life grant cycle and involves a student-written research proposal, evaluation of proposals by panels of experts, panel review reports, announcement of awards, work on the actual research project with a faculty mentor, and writing a final report detailing research results. The two Ureca! projects funded by the VTSGC all involved research topics that are aligned with NASA research priorities. The topic of the first project, conducted by UVM engineering student Ashley McKhann, was “Forecasting Regime Changes in a Physical Toy Climate.” The second project, conducted by UVM Engineering student Trevor Avant, was titled “Atomistic Simulation Study of Indentation of Nickel Nanowires.”

Comments collected from students by the National Space Grant Foundation during the course of compiling the VTSGC’s 2010 Longitudinal Tracking data, indicate that our Higher Education programs appear to have had a significant impact in encouraging supported students to pursue STEM careers. Answers to the question “How did participation in these programs impact your education and life?” included:

“Space Grant has really helped to make my education possible.” (Nyoka Bertrand, 2008 & 2009 Vermont Space Grant Scholarship recipient, UVM),

“I believe the Space Grant Program was critical in getting my current job and being accepted into Stanford for graduate school.” (Travis Gang, 2006 & 2007 URECA! Awardee , UVM), and

“It allowed me to complete my undergraduate degree. I am currently working on my graduate degree in history and am a member of the governor's commission on Native American Affairs in Vermont” (Melody Walker, 2003 & 2004 Vermont Space Grant Scholarship recipient, UVM).

Outcome 2: Attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers, and faculty (Educate and Engage)

VTSGC activities this past year in our Higher Education and Precollege programs that contributed to this outcome are described in the following two sub-headings:

2.1 Higher Education Programs:

Components of several of the VTSGC programs described above give undergraduate students in STEM disciplines a greater appreciation for the breadth and depth of NASA's mission as well as an appreciation for the challenges presented by NASA-related research. In particular, as mentioned previously, faculty investigators in several of our FY 2010 Faculty Research Awards have actively engaged their undergraduate students by involving them in significant ways in their funded research projects. VTSGC research support thus provides new educational opportunities for these students and strengthens both the desire to pursue a career in a STEM discipline and, in some cases, the desire to go on to earn an advanced degree. The mentored undergraduate research projects described in the section above also directly educate and engage students at both a research university and two primarily undergraduate institutions in a way that would not be possible without VTSGC sponsorship.

In FY 2010, the VTSGC has also been instrumental in providing a new avenue for Vermont students to explore a progression of educational opportunities that could lead to a career in a STEM discipline. In particular, through the efforts of the VTSGC, UVM's Office of Career Services was granted a license to use the Pathevo STEM software system. This software system, developed by Owens Software of Rockville, MD in partnership with the National Space Grant Foundation, is a next generation Career and Education Decision Support solution that will significantly improve students' career and education planning, from Middle School through College. It is the only solution currently available that allows students to intelligently identify matching STEM career alternatives and then design specific education paths that will prepare them for their chosen career. Pathevo-STEM also supports collaboration among the student and their parents, counselors and advisors. The result of Pathevo-STEM use is expected to be enhanced and improved education and career counseling and advising, and significantly better STEM education and career decisions by students.

2.2 Precollege Programs:

Vermont is a small, predominantly rural state without a well-developed statewide research culture. There are only 82 high schools in the entire state, and, in many school districts, students are not fully aware of opportunities for scientific and technical careers. VTSGC precollege programs are able to access Vermont students at a key location in the pipeline leading to professional careers. Our data shows that the summer enrichment programs we have partially supported during the course of our training grant, particularly the Summer Mathematics Institute (which has now become a part of the Governor's Summer Institutes in Science and Mathematics) and an underrepresented minority component for the UVM College of Engineering and Mathematics Summer Enrichment Program in Science and Technology, have been successful in motivating precollege students from across the State. Further, the positive publicity in the press generated by

these programs has increased the visibility of NASA throughout the State and facilitated our efforts at both the higher education and research infrastructure levels. The VTSGC is a founding member of the Vermont-NASA Educational Cooperative (VNEC), a group of organizations with ties to NASA and agendas that involve education at the K-12 level. We also helped to promote an interest in science among Vermont's Middle School students by our participation and support in the Junior Solar Sprint program, a project for students in grades 5 through 8 involving the design, building, and racing of mini solar/electric cars. Our Program Coordinator, Ms. Laurel Zeno has acted as Northern Vermont Area Coordinator for this program. VTSGC participation in this event includes donation of the Trophies and Certificates as well as help with the fundraising from the private sector that makes this event possible.

Two events coordinated by UVM's College of Engineering and Mathematical Sciences (CEMS) that involved the VTSGC occurred in 2010: Design Technology And Society Connection (TASC) and E-Week. Design TASC is held annually at UVM. The purpose of this competition is to give teams of high school students the challenge and satisfaction of designing, building, and testing a device to perform a specified task. The program begins in September and culminates in December when schools bring teams (maximum of five students per team) to UVM to display the devices they have created. The 2010 E-Week was held in February at the Vermont Air National Guard's Burlington facility with approximately 500 students from 35 elementary, middle and high schools in attendance. Activities included building a pasta bridge, an edible car, design of a hangar roof truss, and wind turbine and passive helicopter drop competitions. Both then Governor Jim Douglas and then Lieutenant Governor Brian Dubie attended this event. The VTSGC mounted an exhibit showcasing our programs at these events and also provided a small amount of funding support. Other precollege programs in which the VTSGC was involved during the present reporting period included the Governor's Youth Leadership Conference and the ACE Camp run by VT Department of Transportation and Aviation.

As a CAPENS Consortium, the VTSGC expends only a small percentage of our own funding on precollege activities. Our strategy in this area is to work whenever possible through affiliates such as the Vermont State Mathematics Coalition, the Fairbanks and Montshire Museums, and the Franklin Northwest Supervisory Union Indian Education Office. However, through the donated time of the Director and program staff and our collaboration with these affiliates, the VTSGC has been able to establish a strong presence in the state and region in the K-12 arena.

Outcome 3: Build strategic partnerships and linkages between STEM formal and informal education providers that promote STEM literacy and awareness of NASA's mission (Engage and Inspire)

3.1 General Public and External Relations Programs:

To give NASA programs prominent exposure in the state and help engage and inspire the next generation of STEM practitioners, the VTSGC invites special guests to Vermont to address local audiences. NASA representatives who visited Vermont in FY 2010

included Dr. David Chuss of the NASA Observational Cosmology Laboratory at NASA Goddard. Dr. Chuss was a keynote speaker in the VTSGC's 2010 Awards Night Ceremonies. His participation in this event, as well as surrounding activities that included the VTSGC Student Poster Session and a seminar held the following day, helped to facilitate opportunities and interactions between GSFC and Vermont students, teachers, and academic researchers.

The VTSGC has been named a full member of the Vermont Academy of Science and Engineering (VASE), a component of the Vermont Technology Council that advises the State of Vermont on science and technology policy. Consortium Director William Lakin was invited to participate in a recent VASE review and revision of Vermont's official Science and Technology Plan, and Program Coordinator Laurel Zeno represents the VTSGC at the quarterly meetings of the Council.

Additional outreach within the State has come from the VTSGC's interactions with civilian aviation interests and the Civil Air Patrol in Vermont. Vermont's former Lieutenant Governor, Brian Dubie, a commercial airline pilot and continuing National Chair of the Aerospace States Association, expressed a particular interest in this portion of the VTSGC's activities before leaving office in late 2010. The VTSGC's Program Coordinator, Ms. Laurel Zeno, is our point person for interactions in this area. Ms. Zeno is a member of the Aero Club of New England and serves as the VTSGC's representative on the Board of Burlington Technical Center's Aviation Technology School. The VTSGC has played a key role in promoting the expansion of the Aviation Technology School's facility at the Burlington Airport. Indeed, we are one of a group of stakeholders that submitted a successful proposal to the State for funds to support an expansion. The proposed new facilities will not only benefit the Aviation Technology School, but will also be used by students in Vermont Technical College's new Aerospace Engineering Technology major, a degree program that owes its existence to an interaction of VTC and BTC through the Vermont Space Grant network. The VTSGC has also interacted with the NASA Explorer School in Orleans, Vermont.

A final note of interest is that as NASA ends the Space Shuttle Program, the VTSGC has applied for, and been awarded, a tile from a shuttle's heat shield. When this tile arrives here in March, the VTSGC will be hosting a "Welcome to Vermont" event that will celebrate the accomplishments of this NASA program and be attended by representatives from schools, government, and the private sector from across the state.

NASA 2010 Education Priorities: A number of the accomplishments detailed above are directly related to the "Current Areas of Emphasis" stated in the 2010 Space Grant solicitation. These include:

VTSGC support for two capstone undergraduate engineering design projects (Greenland Robot Tractor and Miniaturized Liquid Gyroscope) and two student engineering teams (AERO at UVM and AUV at Norwich) provided authentic, hands-on student experiences in science and engineering disciplines based on real-life NASA research and technology needs.

Our support for an underrepresented minority component for the UVM College of Engineering and Mathematics Summer Enrichment Program in Science and Technology provided a summer opportunity for secondary students on a college campus with the objective of increased enrollment in STEM disciplines or interest in STEM careers while simultaneously promoting VTSGC Diversity goals.

Continued VTSGC support for faculty and students (both undergraduate and graduate) involved in an “Analysis of Arctic Sea Ice Dynamics Using NASA Satellite Data” and the development of an “Arctic Sea Ice Monitoring Buoy” addressed the priority related to Environmental Science and Global Climate Change by promoting research and activities to better understand Earth's environments.

Funding awarded to Vermont's NASA EPSCoR project in FY 2007 produced a significant advance in Vermont's research infrastructure with the development over the last two years of a 30 kW Inductively Coupled Plasma (ICP) facility at UVM to study the ablation of aerospace materials used in heat shields under atmospheric reentry conditions. As a result of the close cooperation and coordination of the VTSGC with VT-NASA EPSCoR, a Graduate Fellowship was awarded by the VTSGC to a student who is working with an Assistant Professor at UVM on this ablation project. This VTSGC funding will help enable this early career faculty researcher to focus his research program toward NASA priorities. A Research Minigrant awarded by the VTSGC to Prof. Mary Dunlop, a new Ph.D. in Biomedical Engineering just hired by UVM's SoE, will likewise allow an early career faculty member to explore the initiation of research aligned with new and continuing NASA research priorities.

PROGRAM CONTRIBUTIONS TO PART MEASURES

- Longitudinal Tracking: The VTSGC fully recognizes the importance of providing the National Program with accurate data that longitudinally tracks students supported by our programs. Therefore, we have contracted with the National Space Grant Foundation to longitudinally track participating students. The following tracking data provided us by the Foundation for Significant Awards to students indicates that in FY 2010 these awards were concentrated in our Fellowship and Scholarship programs. However, this is somewhat misleading as our Graduate Fellowships have a strong Research Infrastructure component. In particular, graduate students awarded VTSGC Fellowships work directly with their faculty advisors on research projects that are aligned with new and continuing NASA research priorities.

Significant awards in FY 2010: Total awards = 28 (20 Undergraduate, 8 Graduate); Fellowship/Scholarship = 28; Higher Education/Research Infrastructure = 0; 4 of the total awards represent underrepresented minority F/S funding. During the FY10 program year 2 students have accepted STEM positions in industry, 1 accepted a STEM position in academia, 2 are working in a non-STEM fields, and 3 graduated and are pursuing advanced STEM degrees. For all students that were significantly supported in the period spanning FY06-FY10, 8 students graduated and are pursuing advanced STEM degrees, 1 accepted a position at a NASA contractor, 10 accepted

STEM positions in industry, 2 accepted STEM positions in academia, and 3 are working in non-STEM fields. The remaining students have not yet received the degree that they were pursuing while they received their Space Grant award.

- **Course Development:** FY 2010 VTSGC funding has directly supported the development of two new capstone senior design courses in the School of Engineering at UVM. In the first of these, Prof. Darren Hitt is mentoring students as they develop a Miniaturized “Moving-Liquid” Gyroscope for use in Nanosat applications. In the second, Prof. Jeff Frolik is mentoring students who are developing robotic guidance and control systems for a robotic tractor that will be used by NASA scientists on the Greenland ice shelf for cryospheric studies. This second capstone course has also produced an opportunity for a graduate student to have a summer internship in 2011 at NASA Goddard. VTSGC support for the UVM AERO Team has also led indirectly to new senior design courses. In AY 2009-2010, AERO-sponsored its second senior design project, and a third AERO-sponsored senior design project is currently underway. Finally, research results obtained with VTSGC small-scale grant funding have been integrated into the undergraduate classroom at St. Michael’s College. A paper by Profs. Joanna Ellis-Monaghan and Greta Pangborn entitled “Using DNA Self-Assembly Design Strategies to Motivate Graph Theory Concepts” that describes this integration will appear in the journal *Mathematical Modeling of Natural Phenomenon*.
- **Matching Funds:** The ratio of matching funds to NASA funds in our aggregated FY 2010 base funding and augmentation proposals was 0.76 to 1.
- **Minority-Serving Institutions:** Vermont has an exceptionally homogeneous population. Demographic tables from the 2000 US Census show that only 2.3% of Vermont residents identify themselves as members of an underrepresented minority in STEM areas while data from the National Center of Education Statistics Digest indicates that only 2.5% of students enrolled in Vermont (in-state and out-of-state) are Black, Hispanic, or Native American. Vermont has no minority-serving higher educational institutions, or indeed any higher educational institutions with a significant percentage of minority student enrollment. As will be noted shortly in the Program Partners Section, one VTSGC strategy for promoting diversity in our programs involves a strong working relationship developed over the past ten years with the Franklin Northwest Supervisory Union Indian Education Office, the Education Arm of the Abenaki Tribal Council of Northern Vermont. The FNWSUIEO, which is now a VTSGC affiliate, cooperates closely with the VTSGC and each year helps us to attract talented students of Abenaki Heritage to our Undergraduate Scholarship application pool. Indeed, in our affiliate structure, the FNWSUIEO plays a role similar to a “Tribal College.” A second part of the VTSGC’s strategy for promoting diversity in our programs involves developing relations with minority-serving institutions out-of-state. In particular, the VTSGC has worked through the New York Space Grant Consortium to conduct joint weather balloon launches with Medgar Evers College, part of the City University of New York for the Central Brooklyn community. In joint CricketSat workshops for undergraduate students, Vermont and New York students work on the assembly and

calibration of CricketSat temperature sensors as well as conducting flights.

IMPROVEMENTS MADE IN THE PAST YEAR

During the present reporting period, we have begun to implement an expanded strategy for assessing the impact and outcomes of our funding in program components that involve undergraduate and graduate student participation. In addition to gathering standard evaluation metrics, such as presentations given, degrees conferred, and papers written, a new aspect of our evaluation and assessment plan is seeking to determine the “delta” in both interest in NASA and the motivation to pursue an aerospace-related career created by interactions between the students and the VTSGC through our programs and projects. Quantitative methods alone are not adequate for this determination. Dr. Jeffrey Benay, a Partner in J & J Educational Consultants of Fairfax, Vermont and an internationally recognized expert in STEM program evaluation design and implementation, is carrying out this portion of our evaluation plan. Dr. Benay is also a member of the VTSGC Board of Advisors and a past Chair of the Governor’s Commission on Native American Affairs.

The evaluation approach that Dr. Benay will employ is an integrated "systems" matrix that draws on a myriad of qualitative and quantitative methodologies (mixed method evaluation plan). Within this framework, the use of interviews with students will provide raw data that, when transcribed and analyzed, will yield measures of the efficacy of our programs in terms of our impacts on students, faculty, and the NASA-related community. In addition, site visits and material review are assisting in the formation of an ongoing, fluid evaluation process that is examining the overall planning, implementation, and outcomes of the SMART objectives for this project. Both formative and summative evaluation cycles will promote dynamic communication feedback loops that will keep all stakeholders abreast of the grant's progress.

Because of privacy constraints, Dr. Benay is prohibited from contacting students directly to arrange interviews for subsequent analysis. He is therefore working through both faculty mentors and VTSGC affiliate contacts, who are urging all participating students to initiate contact with Dr. Benay and arrange for interviews. Because of the multiple research sites involved in this project, many of these interviews will be done remotely, but face-to-face, using Skype.

In a related development, the VTSGC has now crossed the digital divide to take account of evolving student trends in social networking. Ms. Vanetta Darby, our website designer and IT consultant, has now put the VTSGC on Facebook to advertise our 2011 Undergraduate Scholarship Competition. We will also be using Twitter to encourage students to interact with us and have sent out Tweets as well as emails to announce our 2011 Competition.

PROGRAM PARTNERS AND ROLE OF PARTNERS IN PROJECT EXECUTION

The University of Vermont is the VTSGC's Lead Institution and Fiscal Agent, and we are based in UVM's College of Engineering and Mathematical Sciences. Academic affiliates include: St. Michael's College, a Liberal Arts college in Colchester, VT; Norwich University, a comprehensive school with engineering programs in Norwich, VT; Vermont Technical College (VTC), part of the Vermont State College System in Randolph, VT; and the Aviation Technology School of the Burlington Technical Center (BTC), one of this country's premier programs leading to FAA Airframe & Powerplant Certification. The VTSGC and NASA thus have a presence at academic institutions throughout the state.

Other educational organizations that are VTSGC affiliates are the Vermont State Mathematics Coalition, the Fairbanks Museum and Planetarium, the Montshire Museum, and the Franklin Northwest Supervisory Union Indian Education Office (FNWSUIEO). The Vermont State Mathematics Coalition is composed of teachers at all levels, school board members, representatives from state agencies, and private sector representatives who are concerned with advancing Vermont's STEM education base. The linkage of this coalition with the statewide Space Grant network allows the VTSGC to be a stakeholder in K-12 education with only a small outlay of our own funding. The Fairbanks Museum and Planetarium and the Montshire Museum are both informal education providers with highly successful, nationally acknowledged programs serving the general public. The FNWSUIEO promotes the educational objectives of the Abenaki Tribal Council of Northern Vermont. As Vermont has no Minority Serving Institutions, or indeed any Higher Educational institution with a significant percentage of students from underrepresented minorities, the active participation of the FNWSUIEO as a full affiliate in our network greatly enhances our goal to engage diverse populations in VTSGC programs. Industrial affiliates of the VTSGC include Triangle Metal Fabrications of Milton, VT and Microstrain, Inc. of Williston, VT. Both of these companies have provided significant support and training for VTSGC-supported student engineering teams.